

## DESCRIPTION

## ANTI-CORONAVIRUS AGENT

5 Technical Field

The present invention relates to an anti-coronaviral agent that is effective in treating coronaviruses and can be mixed with plastics, paints and the like. It also relates to an anti-coronaviral product made from fibers, resins and others that contain the anti-coronaviral agent.

Background Art

In recent years, various infectious diseases have become social problems. In particular, there is no vaccine or no causal treatment yet against Severe Acute Respiratory Syndrome (SARS) which is caused by SARS coronavirus and was epidemic in Southeast Asia, and therefore it is very important to prevent the infection.

20 There have been reports that SARS infections could be spread not only through direct contact with or by droplet infection from infected persons but also through indirect contact via door knobs, clothing and other articles which infected persons have touched. According to the first data collected by the network of WHO collaborating centers on stability and resistance of SARS coronavirus, SARS coronavirus can survive for a few

days outside the body in certain conditions. Therefore,  
for the purpose of preventing the infection, it is  
considered effective to keep clean the articles which  
would be frequently touched by infected persons by means  
5 of disinfection and the like.

It has been reported that ethanol, sodium  
hypochlorite, iodophor, peracetic acid, formaldehyde,  
glutaraldehyde and ethylene oxide gas are effective as  
disinfectants against SARS coronavirus. However, these  
10 disinfectants are effective only temporarily and thus  
may be useful only when a coronavirus is apparently  
placed there. Since these disinfectants are not  
expected to have sustained efficacy, they are  
problematic in that they are not always able to maintain  
15 various articles in clean condition.

On the other hand, silver-based inorganic anti-  
microbial agents have been known as anti-microbial  
agents that have sustained efficacy against bacteria.  
The silver-based inorganic anti-microbial agents are  
20 anti-microbial agents which comprise silver carried on  
an inorganic compound. They can be processed into  
various useful product forms because of their high heat  
resistance. As examples thereof, active charcoal on  
which silver and/or silver compounds are carried (for  
25 example, refer to JP Patent Publication (Kokai) No. 49-  
61950), soluble glass containing silver (for example,  
refer to JP Patent Publication (Kokai) No. 63-307807),

zeolite containing silver, copper and/or zinc (for example, refer to JP Patent Publication (Kokai) No. 60-181002), zirconium phosphate containing silver (for example, refer to JP Patent Publication (Kokai) No. 3-83905) may be mentioned. However, it has not been reported that these silver-based inorganic antimicrobial agents are effective against coronaviruses such as SARS coronavirus.

It has been reported that silver nitrate is effective against HSV (herpes simplex virus) -1 and -2, but is not effective against Vacciniavirus, Adenovirus, VSV, Poliovirus or HVJ (for example, refer to R. B. Thurman, C. P. Gerba, "The Molecular Mechanisms of Copper and Silver ion Disinfection of Bacteria and Viruses", Critical Reviews in Environmental Control, 1989, Vol. 18, No. 4, p.295-315).

#### Disclosure of the Invention

An object of the present invention is to provide an anti-viral agent which is effective against a coronavirus and can be expected to have sustained efficacy when it is processed into various products.

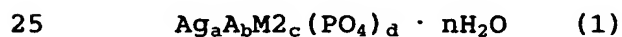
The present inventors have performed intensive researches in order to solve the above problem and have found that the problem can be solved by using a silver ion as an active ingredient and having the silver ion

stably held by a carrier. Thus, the present inventors have completed the present invention.

The present invention relates to an anti-viral agent effective against a coronavirus, which is characterized in that it comprises a carrier which holds a silver ion stably. The present invention relates to a product containing an anti-coronaviral agent, which is useful for inactivating a coronavirus, and also relates to a method for inactivating a coronavirus using the silver ion carrier according to the present invention.

The present invention has been completed based on the above findings and is shown below.

1. An anti-coronaviral agent which comprises a silver ion carrier.
2. The anti-coronaviral agent according to the above item 1, wherein the aforementioned silver ion carrier is at least one selected from a compound represented by the following formula (1), potassium titanate, potassium uranate, potassium vanadate, potassium niobate, sodium tangustate, magnesium molybdate, calcium pentaborate, aluminosilicate, aluminum phosphate, nickel hexacyanoferrate, sepiolite, montmorillonite, silica gel, zeolite,  $\beta$ -alumina, titanium oxide hydrate, hydroxyapatite and a glassy carrier:



wherein A is at least one m-valent ion (m is a positive integer) selected from an alkali metal ion, an alkali

- earth metal ion, an ammonium ion and a hydrogen ion; M<sub>2</sub> is an ion of a tetravalent metal such as zirconium and titanium; n is a number satisfying the condition of  $0 \leq n \leq 6$ ; a and b are positive numbers satisfying a condition of  $a + mb = 1$  or  $a + mb = 2$ ; and  $c = 2$  and  $d = 3$  when  $a + mb = 1$ , and  $c = 1$  and  $d = 2$  when  $a + mb = 2$ .
3. The anti-coronaviral agent according to the above item 1, wherein the aforementioned silver ion carrier is at least one selected from a compound represented by the formula (1), silica gel, zeolite and a glassy carrier.
4. The anti-coronaviral agent according to the above item 1, wherein the aforementioned silver ion carrier is a compound represented by the formula (1).
5. An anti-coronaviral agent according to any one of the above items 1 to 4, wherein the coronavirus is SARS virus.
6. A product comprising the anti-coronaviral agent according to any one of the above items 1 to 4.
7. The product according to the above item 6, comprising the anti-coronaviral agent, wherein the coronavirus is SARS virus.
8. A method for inactivating a coronavirus, which comprises using the anti-coronaviral agent according to any one of the above items 1 to 4.
9. A method for inactivating a coronavirus according to the above item 8, which comprises using the anti-

coronaviral agent, wherein the coronavirus is SARS virus.

Best Mode for Carrying Out the Invention

5       The present invention will be described below.

          Cornavirus in the present invention means a single stranded (+) RNA virus of the Coronavirus family including the genus Coronavirus and genus Torovirus. Also included are infectious bronchitis virus (IBV),  
10   feline infectious peritonitis virus (FIP), canine coronavirus (CCV), swine transmissible gastroenteritis virus (TGEV), equine torovirus (EqTV) and the like. This name was given because the viruses have, on the surface of the envelope thereof, projections which show  
15   an appearance resembling the corona of the Sun. The SARS epidemic in Southeast Asia in 2003 was caused by a new species of this coronavirus.

          Silver ion which is an active ingredient of the anti-viral agent of the present invention must be stably  
20   held in its carrier. The sentence "stably held" means that the silver ion is maintained to be in an ionic state regardless of heat (for example, at a temperature of 200°C or below) or water (for example, at a humidity of 10 to 100%) but is not converted to a non-ionic state  
25   exemplified by a metallic or oxidized state.

          The carrier which holds a silver ion stably according to the present invention includes: compounds

represented by the general formula (1), such as zirconium phosphate and the like; oxygen acid salts, such as potassium titanate ( $K_2Ti_2O_5$ ), potassium uranate ( $K_2U_2O_7$ ), potassium vanadate ( $KV_2O_8$ ), potassium niobate ( $KNbO_8$ ), sodium tungstate ( $Na_2W_4O_{13}$ ), magnesium molybdate ( $Mg_2Mo_2O_7$ ) and the like; zeolite-like substances, such as calcium pentaborate ( $Ca_2(B_5O_9)(OH)$ ), graphite, crystalline aluminosilicate, crystalline aluminum phosphate, hexacyanoferrate, sepiolite

10 ( $Mg_8Si_{12}O_{30}(OH)_4(H_2O)_4$ ), silica gel, montmorillonite and the like; hydrated oxide, such as  $\beta$ -alumina ( $Al_2O_3$ ), titanium oxide hydrate ( $TiO_4 \cdot nH_2O$ ), hydroxyapatite ( $Ca_2(PO_4)(OH) \cdot nH_2O$ ) and the like; and soluble glass containing silver.

15       Among the above-described silver ion carriers, compounds represented by the general formula (1), silver containing zeolite-like substances, silver containing soluble glass and the like are preferable, because these hold a silver ion firmly, and zirconium phosphate,

20 silver containing zeolite, silver containing soluble glass and the like are more preferable.

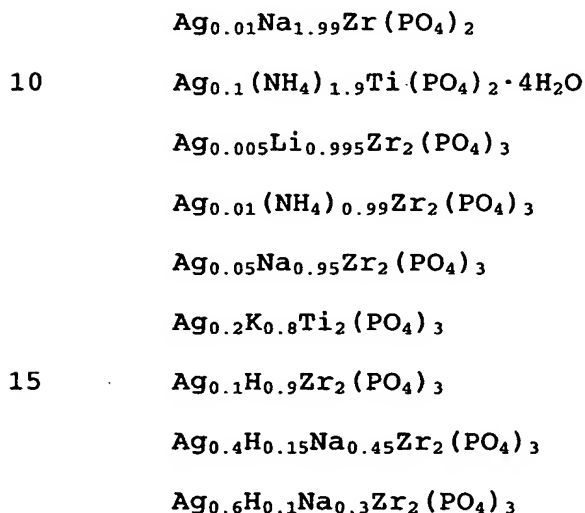
The compounds represented by the above described formula (1) may be obtained from a compound represented by the general formula (2).

25        $A'_xZr_2(PO_4)_3$        (2)

In the formula (2),  $A'$  is at least one metal ion selected from an alkali metal ion, an alkali earth metal

ion or an ammonium ion, x is 1 when A' is monovalent and 1/2 when A is divalent. By immersing this compound in an aqueous solution containing an appropriate concentration of a silver ion at room temperature to 100°C, the compounds represented by the formula (1) can be obtained.

Preferred examples represented by the general formula (1) include the followings:



In the present invention, the silver ion is contained in the silver ion carrier at a concentration of preferably 0.01 to 20% by mass, more preferably 0.05 to 15% by mass and especially preferably 0.1 to 5% by mass. When the silver ion is contained in the silver ion carrier at a concentration of 0.01% by mass or less, anti-viral effect against a coronavirus may not be obtained; when the silver ion is contained therein at a concentration of 20% by mass or more, products containing the silver ion carrier become colored or



economically disadvantageous, and thus these cases are not preferable.

The present anti-coronaviral agent preferably elutes silver ions to water in an amount of 0.5  
5  $\mu\text{g/liter/day}$  or more (per 10 g of the silver ion carrier, for example), and more preferably 5  $\mu\text{g/liter/day}$  or more from the viewpoint of sustainability of the efficacy. However, too much elution of silver ions is not preferable because silver  
10 ions are eluted out beyond necessity for the effect and also because products containing the silver ion carrier are colored.

Further, the particle diameter of the carrier is preferably 0.1 to 15  $\mu\text{m}$  and more preferably 0.5 to 10  
15  $\mu\text{m}$ , because the efficacy is more efficiently exhibited within the range of diameter.

The anti-coronaviral agent according to the present invention can be obtained by mixing and stirring a solution of a silver compound with a carrier such as  
20 zirconium phosphate represented by the general formula (1), potassium titanate, potassium uranate, potassium vanadate, potassium niobate, sodium tungstate, magnesium molybdate, calcium pentaborate, aluminosilicate, aluminum phosphate, nickel  
25 hexacyanoferrate, sepiolite, montmorillonite, silica gel, zeolite,  $\beta$ -alumina, titanium oxide hydrate, and hydroxyapatite. The silver compound which may be used

includes silver nitrate, silver sulfate, silver perchlorate, silver acetate, silver diammine nitrate, silver diammine sulfate and the like. The mixing may be carried out at 10 to 80°C, preferably 40 to 60°C, for 1 to 50 hours, preferably 5 to 24 hours, by batch method or continuous method. After the mixing, the carrier is washed with water and dried at 60 to 170°C. Water soluble glass may also be prepared by allowing it to include silver oxide or the silver compound described above.

Since the anti-coronaviral agent of the present invention is powder, it may be used as it is or after being processed. For example, it may be used in suspension or processed into shaped articles such as particles, paper-like materials, pellets, sheets, films and the like. Also, it may be in a form of porous materials or fibers. Further, it can be processed into paints, cloth, non woven cloth, foam sheets, paper, plastics and inorganic boards.

Production examples of products using the anti-coronaviral agent of the present invention will be described below.

Production examples using silver zirconium phosphate-based carriers

A silver zirconium phosphate-based carrier that contains 3.7% by mass of silver is mixed with polyester resin for fiber in a proportion of 1% by mass, and by a

standard melt spinning method, an anti-coronavirus polyester multifilament composed of 75 of 2 denier filaments can be obtained. From the filament, cloth and paper can be produced.

5        A silver zirconium phosphate-based carrier that contains 3.7% by mass of silver is mixed with polypropylene resin in a proportion of 10% by mass to produce a master batch containing 10% by mass of the carrier. After mixing this master batch with  
10 polypropylene resin in a proportion of 10% by mass, an anti-coronavirus polypropylene molded product can be obtained by a standard injection molding method. The molded product can be used as an anti-coronaviral product.

15        A silver zirconium phosphate-based carrier that contains 3.7% by mass of silver is mixed with UV curing acryl paint in a proportion of 1% by mass to produce an anti-coronavirus UV paint. An anti-coronavirus SUS board can be obtained by painting this anti-coronavirus  
20 paint on a SUS board by a standard method. This anti-coronavirus paint can be used for painting walls, ceilings, floors and the like.

Production examples using silver zeolite Y based carrier

25        A silver zeolite Y based carrier that contains 2.0% by mass of silver is mixed with polyamide resin for fiber in a proportion of 1% by mass, and by a standard melt spinning method, an anti-coronavirus polyamide

multifilament composed of 75 of 2 denier filaments can be obtained. From the filament, cloth and paper can be produced.

A silver zeolite A based carrier that contains 1.1% by mass of silver is mixed with ABS resin in a proportion of 10% by mass to produce a master batch containing 10% by mass of the carrier. After mixing this master batch with ABS resin in a proportion of 10% by mass, an anti-coronavirus ABS molded product can be obtained by a standard injection molding method. The molded product can be used as an anti-coronaviral product.

Production examples using silver glass based carrier

A silver glass based carrier that contains 1.0% by mass of silver is mixed with polyester resin for fiber in a proportion of 0.5% by mass, and by a standard melt spinning method, an anti-coronavirus 30 denier polyester monofilament can be obtained. From the filament, cloth and paper can be produced.

A silver glass based carrier that contains 1.0% by mass of silver is mixed with polystyrene resin in a proportion of 10% by mass to produce a master batch containing 10% by mass of the carrier. After mixing this master batch with polystyrene resin in a proportion of 10% by mass, an anti-coronavirus polystyrene molded product can be obtained by a standard injection molding

method. The molded product can be used as an anti-coronaviral product.

Production examples using silver carrying silica gel based carrier

5        A silver silica gel based carrier that contains 1.1% by mass of silver is mixed with polypropylene resin for fiber in a proportion of 1% by mass, and by a standard melt spinning method, an anti-coronavirus 30 denier polypropylene monofilament can be obtained. From  
10 the filament, cloth and paper can be produced.

      A silver silica gel based carrier that contains 1.1% by mass of silver is mixed with polyethylene resin in a proportion of 10% by mass to produce a master batch containing 10% by mass of the carrier. After mixing  
15 this master batch with polyethylene resin in a proportion of 10% by mass, an anti-coronavirus polyethylene molded product can be obtained by a standard injection molding method. The molded product can be used as an anti-coronaviral product.

20        The products of the present invention can be used in various fields and places where detoxification of coronavirus is desired. For example, they can be used in medical field, cosmetic field, apparel field, bedding field, household field, building material field,  
25 seacraft field, water treatment field and the like. In the medical field, they can be used as medicaments, operation tools, adhesive tapes, containers for medical

wastes, linens and the like. Particular examples of usage of the anti-coronaviral agent of the present invention include doors, floors, walls and the like, as well as medicine wear, gloves, shoe covers, masks, curtains, sheets, towels, dishcloths and the like. It may be integrated as filters into air cleaners, air conditioners and the like.

#### EXAMPLES

The present invention will be further described by way of the following examples.

##### Example 1

A virus inactivation test of a silver zirconium phosphate (Novaron AG300 (trade name) manufactured by Toagosei Co. Ltd.) was carried out against SARS coronavirus (SARS-COV-P11 and SARS-COV-P8) isolated from SARS patients.

##### Monolayer plates of African green monkey kidney cell line VERO E6 (VERO E6 monolayer plates)

4 x 10<sup>5</sup> cells/ml of VERO E6 cells were inoculated to a 96-well plate and cultured in an incubator at 37°C in 5% CO<sub>2</sub> for 24 hours to form a cell monolayer.

##### Toxicity of silver zirconium phosphate against African green monkey kidney cell line VERO E6

Toxicity of silver zirconium phosphate against VERO E6 cells was measured. In particular, 6000 to 187.5 µg/ml solutions of silver zirconium phosphate were prepared in Eagles's cell culture medium and were added

to VERO E6 monolayer plates, and cells were cultured at 37°C in 5% CO<sub>2</sub> for 5 to 7 days. Toxicity was monitored by observing cells under a microscope every day. The results indicated that the toxicity of silver zirconium phosphate was as follows.

$$TD_0 = 1500 \text{ } \mu\text{g/ml}$$

$$TD_{50} = 3000 \text{ } \mu\text{g/ml}$$

#### Toxicity test of SARS coronavirus

Toxicity of SARS-COV-P11 and SARS-COV-P8 against VERO E6 cells was determined according to cytopathic effect (CPE) method to determine TCID<sub>50</sub>.

#### Inactivation of SARS coronavirus by silver zirconium phosphate

To a culture containing SARS coronavirus in an amount of 100 TCID<sub>50</sub> determined as described above, silver zirconium phosphate was added so that it was contained therein at a concentration of 1500 µg/ml. And, the mixture was stirred for 4 and 6 hours. The resultant cultures were serially diluted two folds to prepare the test solutions so that the concentrations of silver zirconium phosphate were 1500 to 23.4 µg/ml equivalent. Each of the test solutions was added to wells of VERO E6 monolayer plates (4 wells were used for each concentration) and cultured at 37°C in 5% CO<sub>2</sub> for 5 to 7 days. During the culturing period, viral CPE was observed under a microscope everyday and the test was terminated when the CPE of the untreated control virus

was 51% or above. The 100% inactivation concentration, 50% inactivation concentration and 25% inactivation concentrations of silver zirconium phosphate against SARS coronavirus were obtained and the results are shown in Table 1 ( $\mu\text{g/ml}$ ).

Table 1

	100% Inactivation	50% Inactivation	25% Inactivation
4 hours	93.75, 93.75	46.8, 46.8	23.4, 23.4
6 hours	93.75, 93.75	46.8, 46.8	23.4, 23.4

The results demonstrate that silver zirconium phosphate was effective against SARS coronavirus at the concentration of 23.4  $\mu\text{g/ml}$  or above.

Production Example

A silver zirconium phosphate-based carrier that contained 3.7% by mass of silver was mixed with polyester resin for fiber in a proportion of 1% by mass, and by a standard melt spinning method, an anti-coronavirus polyester multifilament composed of 75 of 2 denier filaments were obtained.

A silver zirconium phosphate-based carrier that contained 3.7% by mass of silver was mixed with polypropylene resin in a proportion of 10% by mass to produce a master batch containing 10% by mass of the carrier. After mixing this master batch with polypropylene resin in a proportion of 10 mass%, an



anti-coronavirus polypropylene molded product was obtained by a standard injection molding method.

A silver zirconium phosphate-based carrier that contained 3.7% by mass of silver was mixed with a UV curing acryl paint in a proportion of 1% by mass to produce an anti-coronavirus UV paint. An anti-coronavirus SUS board was obtained by painting this anti-coronavirus paint on a SUS board by a standard method.

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#### Industrial Applicability

The anti-coronaviral agent using the silver ion carrier according to the present invention is effective against coronaviruses, durable and heat-resistant. For this reason, it can be processed with plastics and the like, and thus utilized as anti-coronaviral products in various forms. Since coronaviruses already present in or newly entering a room and the like can be inactivated by using the present silver ion carrier, infection can be prevented.

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